Byram River

Watershed Summary

Watershed Description and Maps

The Byram River watershed covers an area of approximately 11,948 acres in the southwestern corner of Connecticut (Figure 1). The watershed is located primarily in Greenwich, CT. Approximately one-third of the upper watershed and a small portion of the lower watershed extend into southeastern New York.

The Byram River watershed includes one segment impaired for recreation due to elevated bacteria levels. This segment was assessed by Connecticut Department of Energy and Environmental Protection (CT DEEP) and included in the CT 2010 303(d) list of impaired waterbodies. The other segment (CT7411-00_02) in the watershed is currently unassessed as of the writing of this document. This does not mean there are no potential issues on this segment, but indicates a lack of current data to evaluate the segment as part of the assessment process. An excerpt of the Integrated Water Quality Report is included in Table 1 to show the status of other waterbodies in the watershed (CT DEEP, 2010).

The Byram River begins at the Byram Lake Reservoir in New York, and flows south through Greenwich to its outlet at Port Chester Harbor at the border of CT and New York. The bacteria impaired segment (CT7411-00_01) consists of 0.49 miles of the river in Greenwich (Figure 2). This impaired segment begins at the outlet to Pemberwick Dam just upstream of the Comley Avenue crossing and the confluence of Byram River and Pemberwick Brook, flows through a residential area parallel to Pemberwick Road, and ends at the inlet to a ponded portion of the river at Caroline Pond just downstream of Upland Street East.

The impaired segment of Byram River has a water quality classification of B. Designated uses include habitat for fish and other aquatic life and wildlife, recreation, and industrial and agricultural water supply. As there are no designated beaches in this segment of the Byram River, the specific recreation impairment is for non-designated swimming and other water contact related activities.

Impaired Segment Facts

Impaired Segment: Byram River (CT7411-00_01)

Municipalities: Greenwich

Impaired Segment Length (miles): 0.49

Water Quality Classification: Class B

Designated Use Impairment: Recreation

Sub-regional Basin Name and Code: Byram River, 7411

Regional Basin: Southwest Western Complex

Major Basin: Southwest Coastal

Watershed Area (acres): 11,948

MS4 Applicable? Yes

Applicable Season: Recreation Season (May 1 to September 30)

Figure 1: Watershed location in Connecticut

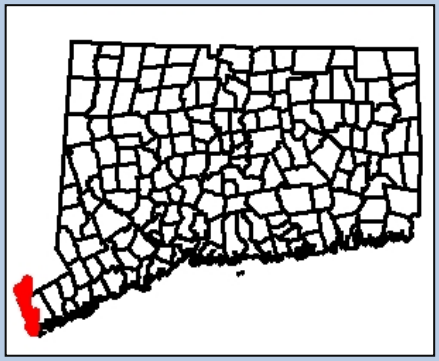


Table 1: Impaired segment and nearby waterbodies from the Connecticut 2010 Integrated Water Quality Report

Waterbody ID	Waterbody Name	Location	Miles	Aquatic Life	Recreation	Fish Consumption
CT7411-00_01	Byram River-01	From head of tide (US of Route 1 crossing, at INLET to ponded portion of river, just DS of Upland Street East area), US to Pemberwick outlet dam (US of Comley Avenue crossing, and US of confluence with Pemberwick Brook, Greenwich.	0.49	NOT	NOT	FULL
CT7411-00_02	Byram River-02	From Pemberwick outlet dam (US of Comley Avenue crossing, and US of confluence with Pemberwick Brook, US to New York border (on eastern side of I684, in marsh), Greenwich. (Segment includes several ponds with dams)	6.95	U	U	FULL

Shaded cells indicate impaired segment addressed in this TMDL

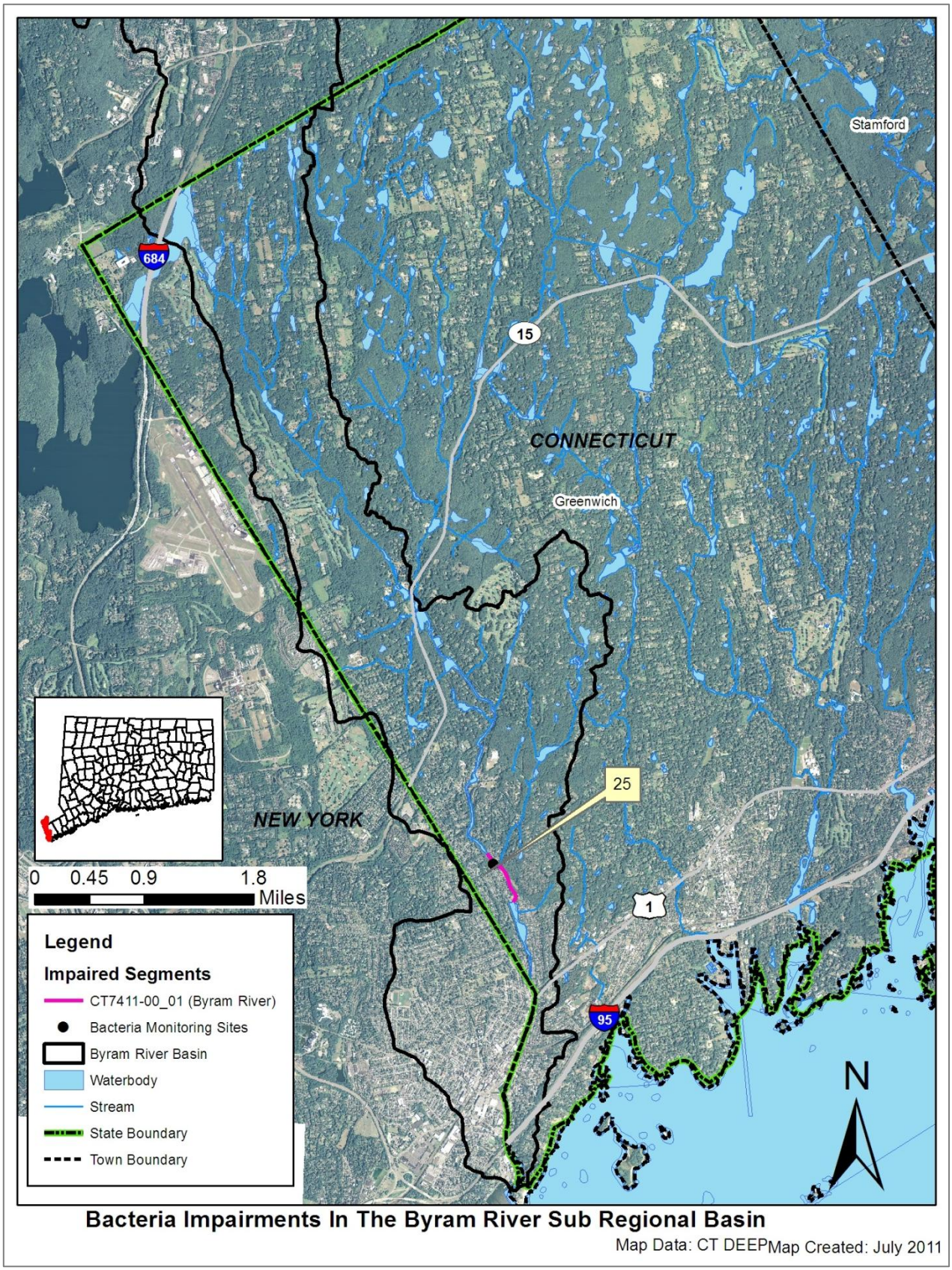
FULL = Designated Use Fully Supported

NOT = Designated Use Not Supported

U = Unassessed

Additional information about the Byram River Watershed can be found in Appendix 74: Greenwich/ Stamford Estuary. This document includes information for CTW1_022-SB, CTW3_015-I, and CTW2_025. Connecting the information between these two appendices provides a better sense of the Byram Watershed from source to Sound.

Figure 2: GIS map featuring general information of the Byram River watershed at the sub-regional level



Land Use

Existing land use can affect the water quality of waterbodies within a watershed (USEPA, 2011c). Natural processes, such as soil infiltration of stormwater and plant uptake of water and nutrients, can occur in undeveloped portions of the watershed. As impervious surfaces (such as rooftops, roads, and sidewalks) increase within the watershed landscape from commercial, residential, and industrial development, the amount of stormwater runoff to waterbodies also increases. These waterbodies are negatively affected as increased pollutants from nutrients and bacteria from failing and insufficient septic systems, oil and grease from automobiles, and sediment from construction activities become entrained in this runoff. Agricultural land use activities, such as fertilizer application and manure from livestock, can also increase pollutants in nearby waterbodies (USEPA, 2011c).

As shown in Figures 3 and 4, the Byram River watershed consists of 54% urban, 38% forest, 6% water, and 2% agriculture land uses. The portion of the watershed in Greenwich, particularly near the impaired segment of the Byram River, is largely characterized by urban and suburban residential land use with small forested areas along the east side of the river segment. North of the intersection of Sherwood Avenue and Riversville Road, land use adjacent to the Byram River is dominated by forest with some urban and agricultural areas. There are larger tracts of developed open spaces, including forested parks, golf courses, nature preserves and horse farms upstream of the impaired segment (Figure 4).

Figure 3: Land use within the Byram River watershed

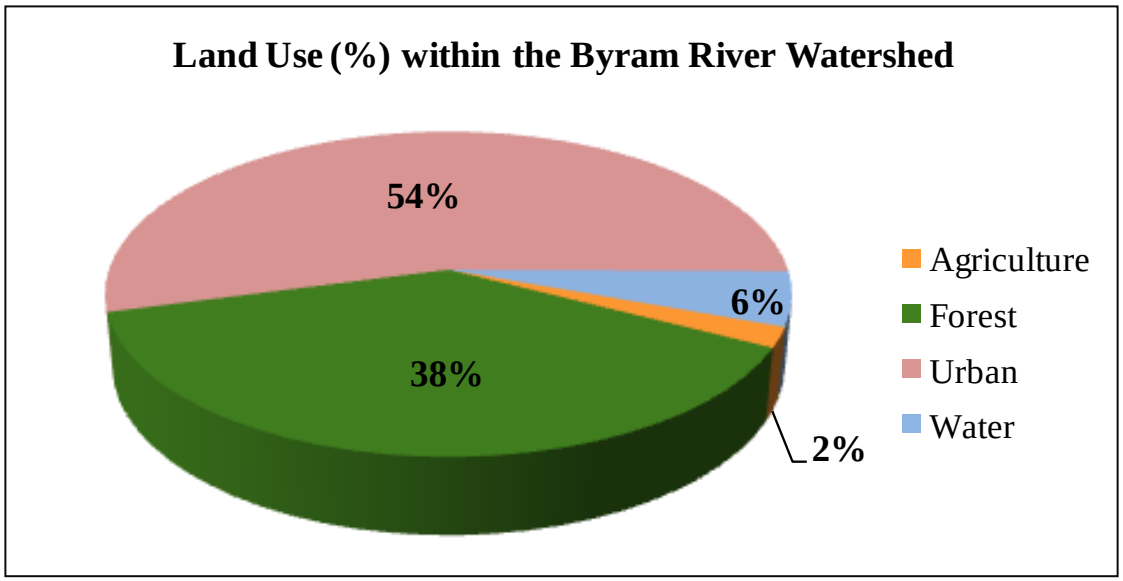
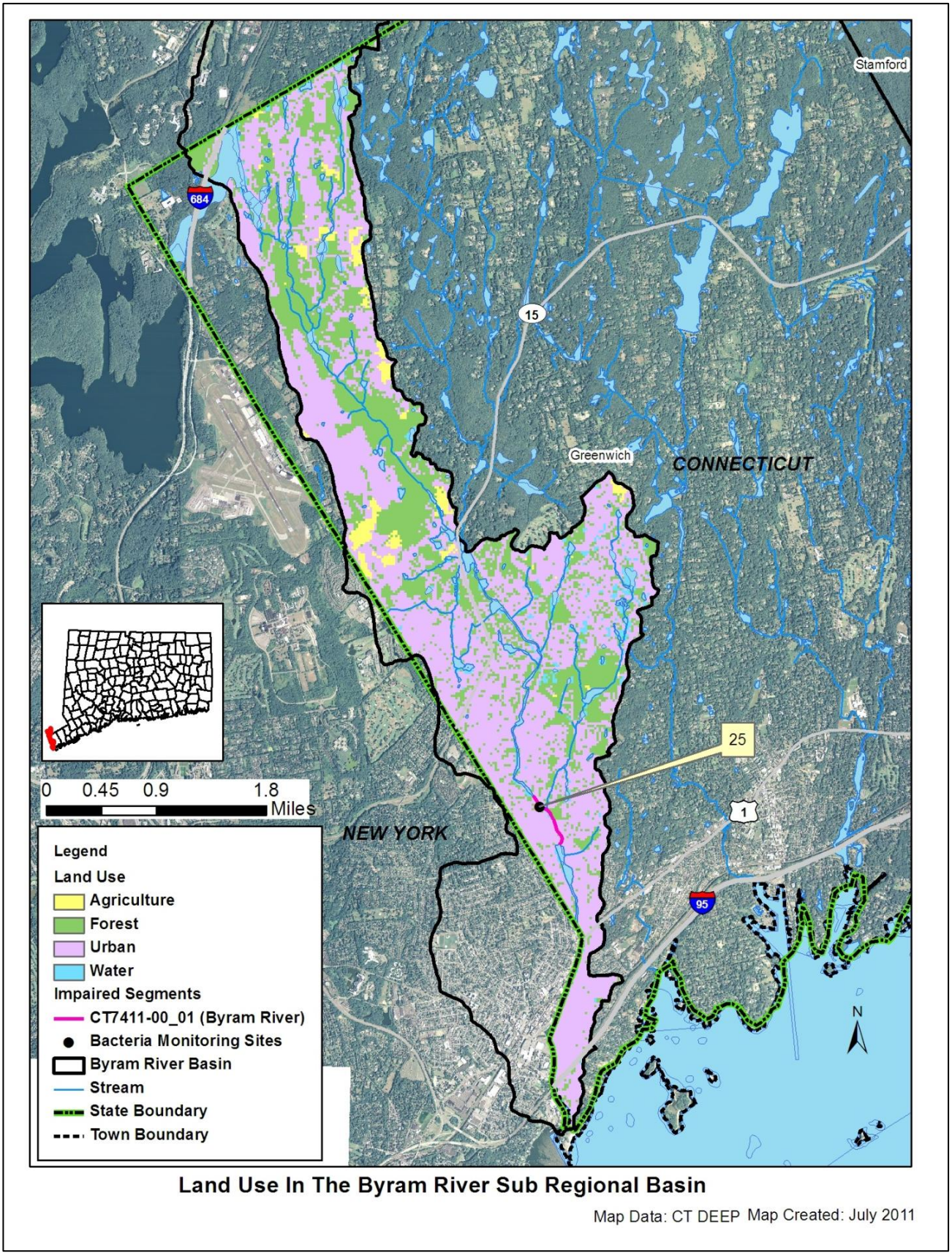


Figure 4: GIS map featuring land use for the Byram River watershed at the sub-regional level



WHY IS A TMDL NEEDED?

E. coli is the indicator bacteria used for comparison with the CT State criteria in the CT Water Quality Standards (WQS) (CTDEEP, 2011). All data results are from CT DEEP, USGS, Bureau of Aquaculture, or volunteer monitoring efforts at stations located on the impaired segments.

Table 2: Sampling station location description for the impaired Segment in the Byram River watershed

Waterbody ID	Waterbody Name	Station	Station Description	Municipality	Latitude	Longitude
CT7411-00_01	Byram River	25	Comley Avenue	Greenwich	41.027647	-73.662106

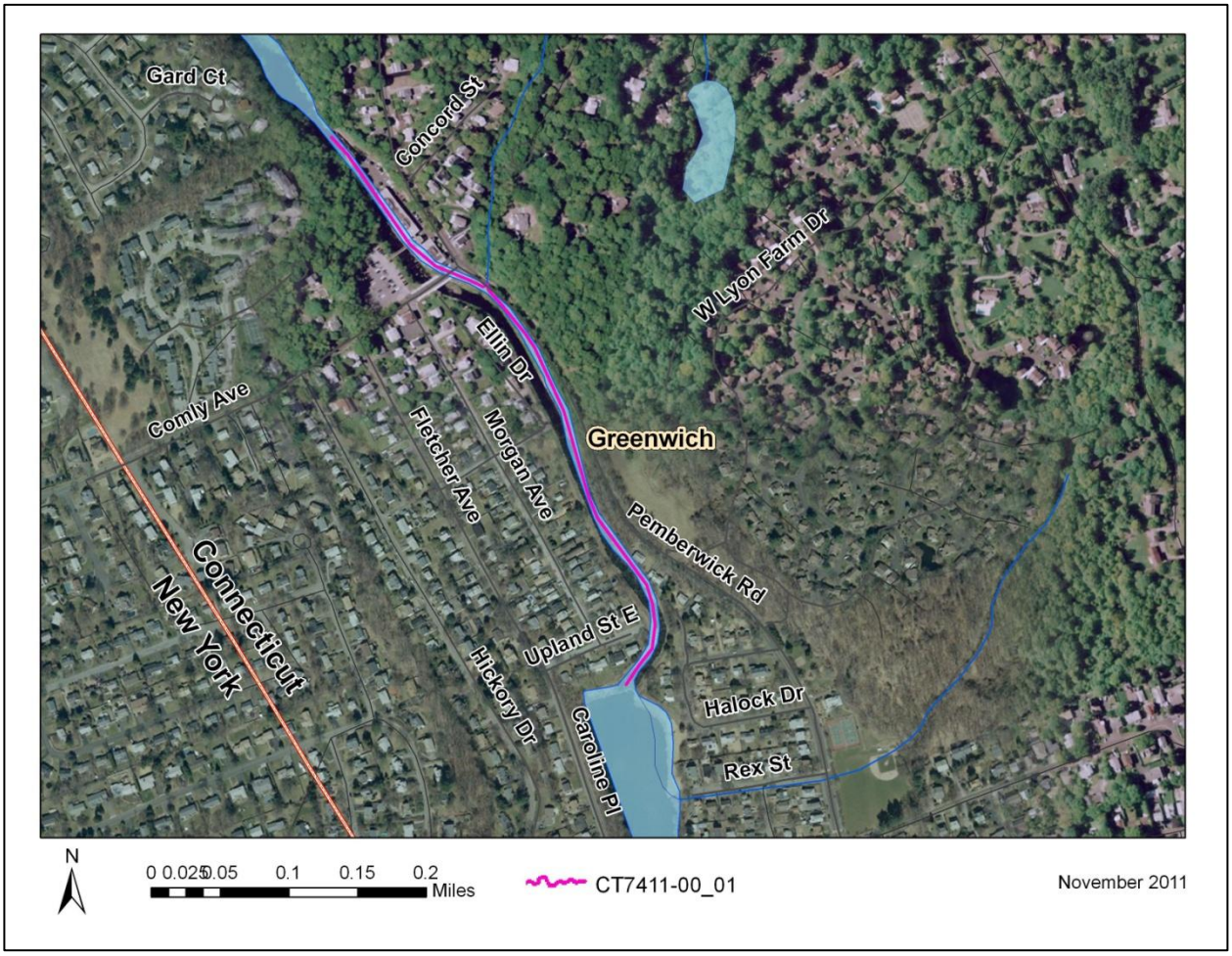
The Byram River (CT7411-00_01) is a Class B freshwater river (Figure 5). Its applicable designated uses are habitat for fish and other aquatic life and wildlife, recreation, and industrial and agricultural water supply. Water quality analyses were conducted using data from one sampling location from 2006-2009 (Station 25) (Table 2).

The water quality criteria for *E. coli*, along with bacteria sampling results for Station 25 from 2006-2009, are presented in Table 12. The annual geometric mean was calculated for Station 25 and exceeded the WQS for *E. coli* for all years. Single sample values at this station also exceeded the WQS for *E. coli* multiple times each year.

To aid in identifying possible bacteria sources, the geometric mean was also calculated for Station 25 for wet-weather and dry-weather sampling days, where appropriate (Table 11). For Byram River, geometric mean values at Station 25 exceeded the WQS for *E. coli* during both wet and dry-weather, with wet-weather values higher than dry-weather values.

Due to the elevated bacteria measurements presented in Table 11, this segment of the Byram River did not meet CT's bacteria WQS, was identified as impaired, and was placed on the CT List of Waterbodies Not Meeting Water Quality Standards, also known as the CT 303(d) Impaired Waters List. The Clean Water Act requires that all 303(d) listed waters undergo a TMDL assessment that describes the impairments and identifies the measures needed to restore water quality. The goal is for all waterbodies to comply with State WQS.

Figure 5: Impaired segment of the Byram River



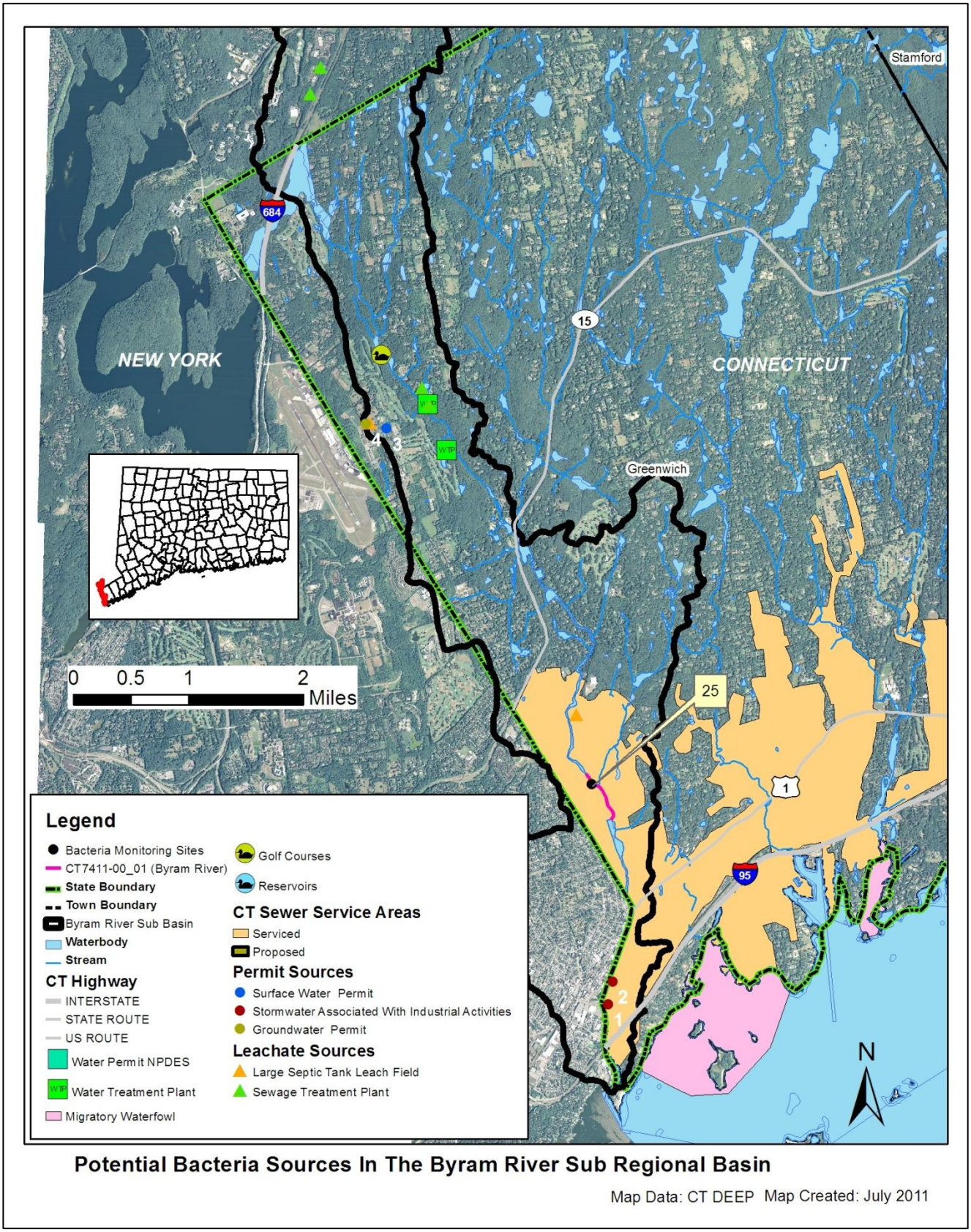
POTENTIAL BACTERIA SOURCES

Potential sources of indicator bacteria in a watershed include point and non-point sources, such as stormwater runoff, agriculture, sanitary sewer overflows (collection system failures), illicit discharges, and inappropriate discharges to the waterbody. Potential sources that have been tentatively identified in the Byram River watershed based on land use (Figures 3 and 4) and a collection of local information for the impaired waterbody is presented in Table 3 and Figure 6. However, the list of potential sources is general in nature and should not be considered comprehensive. There may be other sources not listed here that contribute to the observed water quality impairment in the study segment. Further monitoring and investigation will confirm listed sources and discover additional ones. Some segments in this watershed are currently listed as unassessed by CT DEEP procedures. This does not suggest that there are no potential issues on this segment, but indicates a lack of current data to evaluate the segment as part of the assessment process. For some segments, there are data from permitted sources, and CT DEEP recommends that any elevated concentrations found from those permitted sources be addressed through voluntary reduction measures. More detailed evaluation of potential sources is expected to become available as activities are conducted to implement these TMDLs.

Table 3: Potential bacteria sources in the Byram River watershed

Impaired Segment	Permit Source	Illicit Discharge	CSO/SSO Issue	Failing Septic System	Agricultural Activity	Stormwater Runoff	Nuisance Wildlife/ Pets	Other
Byram River CT7411-00_01	**x**	**x**		**x**	**x**	**x**	**x**	**x**

Figure 6: Potential sources in the Byram River watershed at the sub-regional level



The potential sources map for the impaired basin was developed after thorough analysis of available data sets. If information is not displayed in the map, then no sources were discovered during the analysis. The following is the list of potential sources that were evaluated: problems with migratory waterfowl, golf course locations, reservoirs, proposed and existing sewer service, cattle farms, poultry farms, permitted sources of bacteria loading (surface water discharge, MS4 permit, industrial stormwater, commercial stormwater, groundwater permits, and construction related stormwater), and leachate and discharge sources (agricultural waste, CSOs, failing septic systems, landfills, large septic tank leach fields, septage lagoons, sewage treatment plants, and water treatment or filter backwash).

Point Sources

Permitted sources within the watershed that could potentially contribute to the bacteria loading are identified in Table 4. This table includes permit types that may or may not be present in the impaired watershed. A list of active permits in the watershed is included in Table 5. Additional investigation and monitoring may reveal the presence of additional discharges in the watershed. Available effluent data from each of these permitted categories found within the watershed are compared to the CT State WQS for the appropriate receiving waterbody use and type. When available, bacteria data results from these permitted sources are listed in Tables 6 and 7.

Table 4: General categories list of other permitted discharges

Permit Code	Permit Description Type	Number in watershed
CT	Surface Water Discharges	1
GPL	Discharge of Swimming Pool Wastewater	0
GSC	Stormwater Discharge Associated with Commercial Activity	0
GSI	Stormwater Associated with Industrial Activity	2
GSM	Part B Municipal Stormwater MS4	1
GSN	Stormwater Registration – Construction	0
LF	Groundwater Permit (Landfill)	1
UI	Underground Injection	0

Permitted Sources

As shown in Table 5, there are multiple permitted discharges in the Byram River watershed. Bacteria data from 2002 for one industrial permitted facility are included in Table 6. Though this data cannot be compared to a water quality standard as Connecticut only has a fecal coliform bacteria water quality standard for shellfishing uses, samples from multiple outfalls at Holly Hill Resource Recovery Facility (GSI785) exceeded 50,000 colonies/100mL. Since the MS4 permits are not targeted to a specific location, but the geographic area of the regulated municipality, there is no one accurate location on the map to display the location of these permits. One dot will be displayed at the geographic center of the municipality as a reference point. Sometimes this location falls outside of the targeted watershed and therefore the MS4 permit will not be displayed in the Potential Sources Map. Using the municipal border as a guideline will show which areas of an affected watershed are covered by an MS4 permit.

Table 5: Permitted facilities within the Byram River watershed

Town	Client	Permit ID	Permit Type	Site Name/Address	Map #
Greenwich	Brunswick School, Inc.	UI0000332	Groundwater Permit	The Brunswick School	4
Greenwich	Town of Greenwich	GSM000084	Part B Municipal Stormwater MS4	Greenwich, Town of	N/A
Greenwich	J. Catalano & Sons Inc.	GSI002247	Stormwater Associated With Industrial Activities	J. Catalano And Sons, Inc.	2
Greenwich	Ebb Tide Boat Rental	GSI002294	Stormwater Associated With Industrial Activities	Ebb Tide Boat Rental	1
Greenwich	Fairview Country Club, Inc.	CT0101354	Surface Water Permit	Fairview Country Club, Inc.	3

Table 6: Industrial permits on the Byram River and available fecal coliform data (colonies/100mL). The results cannot be compared to the water quality standard as there is no recreation standard for fecal coliform.

Town	Location	Permit Number	Receiving Water	Sample Location	Sample Date	Result
Greenwich	Holly Hill Resource Recovery Facility	GSI785	Byram Harbor	1	08/29/02	>50,000
Greenwich	Holly Hill Resource Recovery Facility	GSI785	Byram Harbor	2	08/29/02	>50,000
Greenwich	Holly Hill Resource Recovery Facility	GSI785	Byram Harbor	3	08/29/02	>50,000

Municipal Stormwater Permitted Sources

Per the EPA Phase II Stormwater rule all municipal storm sewer systems (MS4s) operators located within US Census Bureau Urbanized Areas (UAs) must be covered under MS4 permits regulated by the appropriate State agency. There is an EPA waiver process that municipalities can apply for to not participate in the MS4 program. In Connecticut, EPA has granted such waivers to 19 municipalities. All participating municipalities within UAs in Connecticut are currently regulated under MS4 permits by CT DEEP staff in the MS4 program.

The US Census Bureau defines a UA as a densely settled area that has a census population of at least 50,000. A UA generally consists of a geographic core of block groups or blocks that exceeds the 50,000 people threshold and has a population density of at least 1,000 people per square mile. The UA will also include adjacent block groups and blocks with at least 500 people per square mile. A UA consists of all or part of one or more incorporated places and/or census designated places, and may include additional territory outside of any place. (67 FR 11663)

For the 2000 Census a new geographic entity was created to supplement the UA blocks of land. This created a block known as an Urban Cluster (UC) and is slightly different than the UA. The definition of a UC is a densely settled area that has a census population of 2,500 to 49,999. A UC generally consists of a geographic core of block groups or blocks that have a population density of at least 1,000 people per square mile, and adjacent block groups and blocks with at least 500 people per square mile. A UC consists of all or part of one or more incorporated places and/or census designated places; such a place(s)

together with adjacent territory; or territory outside of any place. The major difference is the total population cap of 49,999 people for a UC compared to >50,000 people for a UA. (67 FR 11663)

While it is possible that CT DEEP will be expanding the reach of the MS4 program to include UC municipalities in the near future they are not currently under the permit. However, the GIS layers used to create the MS4 maps in this Statewide TMDL did include both UA and UC blocks. This factor creates some municipalities that appear to be within an MS4 program that are not currently regulated through an MS4 permit. This oversight can explain a municipality that is at least partially shaded grey in the maps and there are no active MS4 reporting materials or information included in the appropriate appendix. While these areas are not technically in the MS4 permit program, they are still considered urban by the cluster definition above and are likely to contribute similar stormwater discharges to affected waterbodies covered in this TMDL.

As previously noted, EPA can grant a waiver to a municipality to preclude their inclusion in the MS4 permit program. One reason a waiver could be granted is a municipality with a total population less than 1000 people, even if the municipality was located in a UA. There are 19 municipalities in Connecticut that have received waivers, this list is: Andover, Bozrah, Canterbury, Coventry, East Hampton, Franklin, Haddam, Killingworth, Litchfield, Lyme, New Hartford, Plainfield, Preston, Salem, Sherman, Sprague, Stafford, Washington, and Woodstock. There will be no MS4 reporting documents from these towns even if they are displayed in an MS4 area in the maps of this document.

The list of US Census UCs is defined by geographic regions and is named for those regions, not necessarily by following municipal borders. In Connecticut the list of UCs includes blocks in the following Census Bureau regions: Colchester, Danielson, Lake Pocotopaug, Plainfield, Stafford, Storrs, Torrington, Willimantic, Winsted, and the border area with Westerly, RI (67 FR 11663). Any MS4 maps showing these municipalities may show grey areas that are not currently regulated by the CT DEEP MS4 permit program.

The impaired segment of the Byram River watershed is located within the Town of Greenwich, CT. The town is largely urbanized, as defined by the U.S. Census Bureau, and is required to comply with the General Permit for the Discharge of Stormwater from Small Municipal Storm Sewer Systems (MS4 permit) issued by the Connecticut Department of Energy and Environmental Protection (DEEP) (Figure 7). This general permit is only applicable to municipalities that are identified in Appendix A of the MS4 permit that contain designated urban areas and discharge stormwater via a separate storm sewer system to surface waters of the State. The permit requires municipalities to develop a Stormwater Management Plan (SMP) to reduce the discharge of pollutants and protect water quality. The MS4 permit is discussed further in the "TMDL Implementation Guidance" section of the core TMDL document. Additional information regarding stormwater management and the MS4 permit can be obtained on CTDEEP's website (http://www.ct.gov/dep/cwp/view.asp?a=2721&q=325702&depNav_GID=1654).

Multiple MS4 outfalls have been sampled for *E. coli* bacteria in the watershed (Table 7). In Greenwich, five MS4 outfalls were sampled in 2006 and 2007. Of these outfalls, four exceeded the single sample water quality standard of 410 colonies/100 mL.

Figure 7: MS4 areas of the Byram River watershed

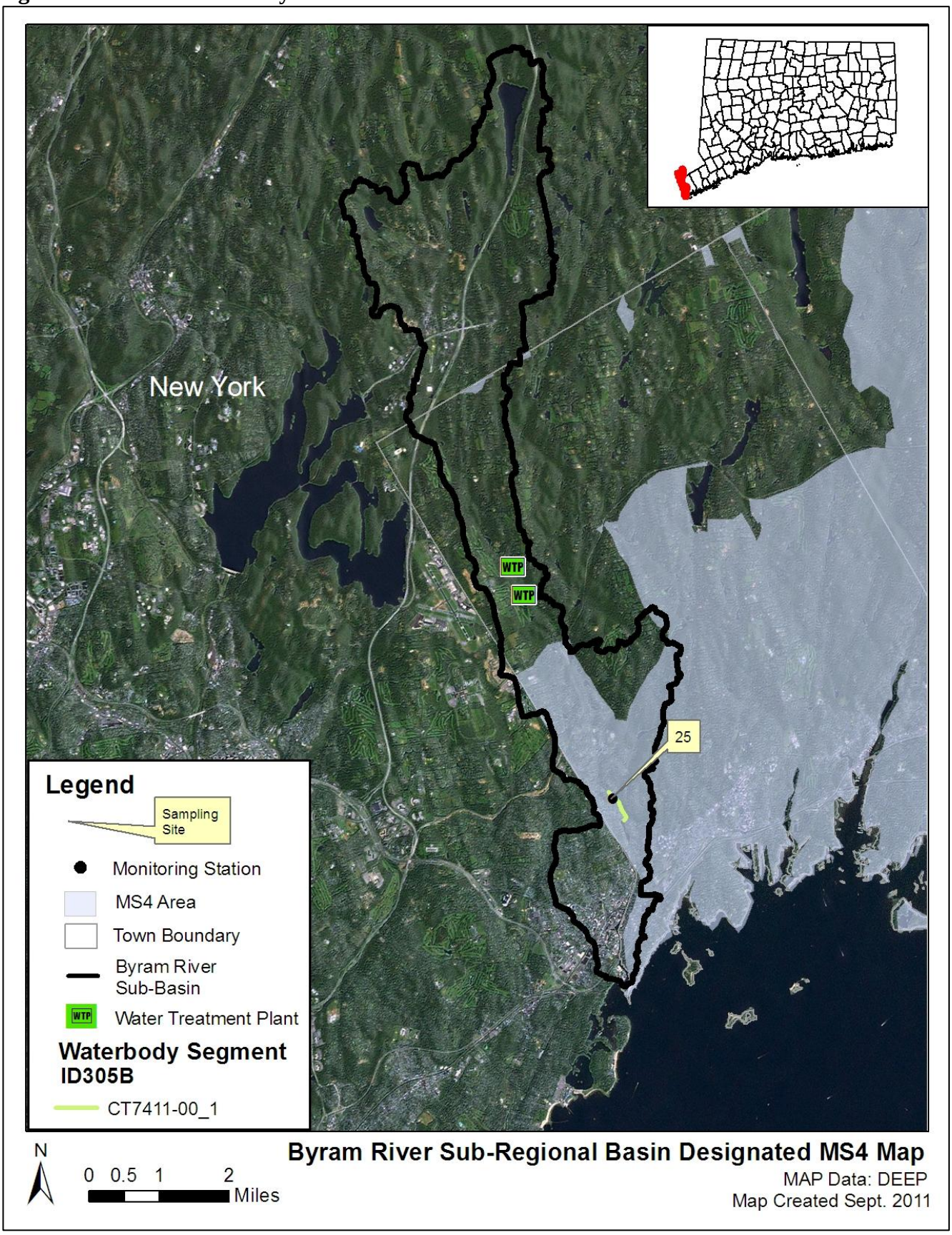


Table 7: List of MS4 sample locations and *E. coli* (colonies/100 mL) results in the Byram River watershed

Town	Location	MS4 Type	Receiving Waters	Sample Date	Result
Greenwich	R-2 John Street, 24" RCP	Residential	East branch Byram River	04/22/06	866
Greenwich	R-3 12" RCP Richmond Hill Road	Residential	East branch Byram River	04/22/06	77
Greenwich	I-7 South Water Street	Industrial	Byram River	09/29/06	980
Greenwich	R-4 John Street	Residential	Byram River	09/29/06	1,553
Greenwich	R9 Dale Drive (sample #4)	Residential	Byram River	08/21/07	691
Shaded cells indicate an exceedance of single-sample based water quality criteria (410 colonies/100 mL)					

Publicly Owned Treatment Works

As shown in Figure 7, there are two publicly owned treatment works (POTWs), or wastewater treatment plants, in the Byram River watershed near the western boundary of Greenwich, CT and north of the impaired segment. The High Tower Water Pollution Control Facility (CT0020800), near Westchester County Airport along King Street, discharges directly to the Byram River, and did not exceed its permit limits on any date sampled (Table 8).

Table 8: Wastewater Treatment Plant fecal coliform (colonies/100 mL) data discharging to the Byram River

Town	Permitee	Permit Number	Receiving Water	Date	30-Day Geometric Mean	7-Day Geometric Mean
Greenwich	High Tower WPCF	CT0020800	Byram River	05/31/2009	5	10
Greenwich	High Tower WPCF	CT0020800	Byram River	07/31/2009	4	8
Greenwich	High Tower WPCF	CT0020800	Byram River	08/31/2009	5	10
Greenwich	High Tower WPCF	CT0020800	Byram River	09/30/2009	2	4
Greenwich	High Tower WPCF	CT0020800	Byram River	05/31/2010	5	10
Greenwich	High Tower WPCF	CT0020800	Byram River	06/30/2010	15	20
Greenwich	High Tower WPCF	CT0020800	Byram River	07/31/2010	60	100
Greenwich	High Tower WPCF	CT0020800	Byram River	08/31/2010	10	20
Greenwich	High Tower WPCF	CT0020800	Byram River	09/30/2010	5	10
Greenwich	High Tower WPCF	CT0020800	Byram River	05/31/2011	4	8
Greenwich	High Tower WPCF	CT0020800	Byram River	06/30/2011	5	10
Greenwich	High Tower WPCF	CT0020800	Byram River	07/31/2011	1	20
Greenwich	High Tower WPCF	CT0020800	Byram River	08/31/2011	5	10
Greenwich	High Tower WPCF	CT0020800	Byram River	09/30/2011	32	42
30-Day Geometric Mean Permit Limit = 200 colonies/100 mL **7-Day Geometric Mean Permit Limit = 400 colonies/100 mL**						

Non-point Sources

Non-point source pollution (NPS) comes from many diffuse sources and is more difficult to identify and control. NPS pollution is often associated with land-use practices. Examples of NPS that can contribute bacteria to surface waters include insufficient septic systems, pet and wildlife waste, agriculture, and contact recreation (swimming or wading). Potential sources of NPS within the Byram River watershed are described below. The 2011 Byram River Watershed Management Plan describes many of these sources in greater detail (http://www.ct.gov/dep/lib/dep/water/watershed_management/wm_plans/byram_wbp2012att.pdf)

Stormwater Runoff from Developed Areas

The majority of the Byram River watershed is developed. Approximately 54% of the land use in the watershed is considered urban, and the impaired segment is located within the densely populated lower half of the watershed (Figures 4 and 9). Urban areas are often characterized by impervious cover, or surface areas such as roofs and roads that force water to run off land surfaces rather than infiltrate into the soil. Studies have shown a link between increasing impervious cover and degrading water quality conditions in a watershed (CWP, 2003). In one study, researchers correlated the amount of fecal coliform to the percent of impervious cover in a watershed (Mallin *et al.*, 2000). According to the Byram River Watershed Management Plan (2011), the increase in development within the watershed has increased stormwater runoff and altered stream channels and floodplains. This creates flash flooding events that increase sedimentation and erosion along the river and damage shoreline property. The greatest alteration to the Byram River in response to flood control measures came with stone rip rapping along the river banks from Pemberwick Dam to Caroline Pond (the impaired segment), which has been exacerbated by erosion from stormwater outflows and culverts along the main stem.

As shown in Figure 8, approximately 27% of the Byram River watershed contains more than 16% impervious cover, particularly in the area around the impaired segment (Figure 9). Station 25 is located within the heavily urbanized portion of the watershed and yielded high geometric mean values during wet-weather, suggesting that stormwater runoff may be a source of bacteria to the Byram River (Table 11).

Figure 8: Range of impervious cover (%) in the Byram River watershed

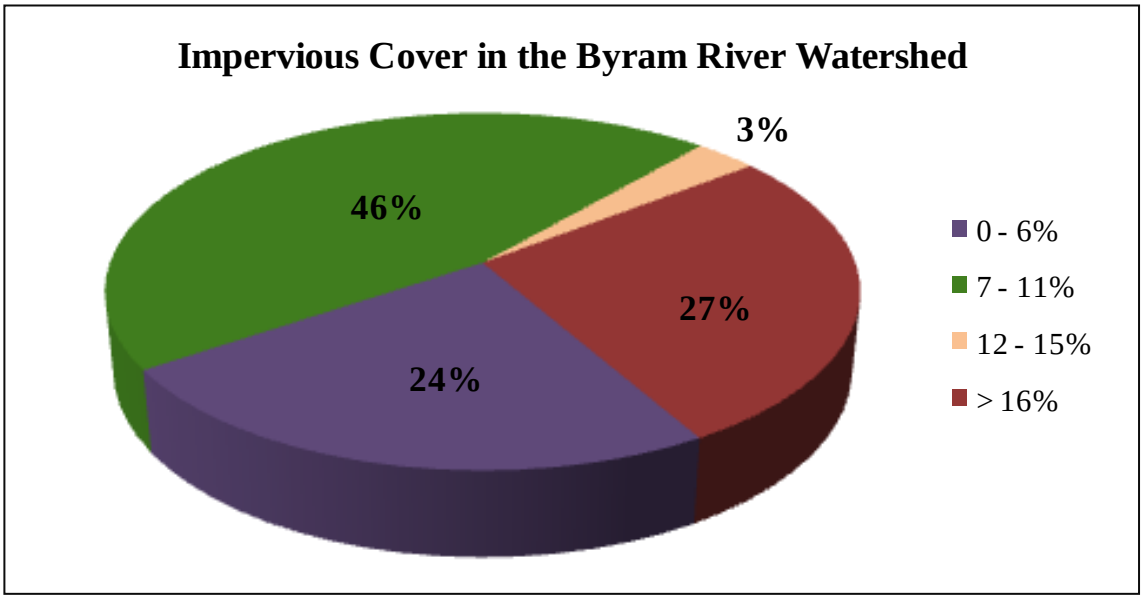


Figure 9: Impervious cover (%) for the Byram River sub-regional watershed

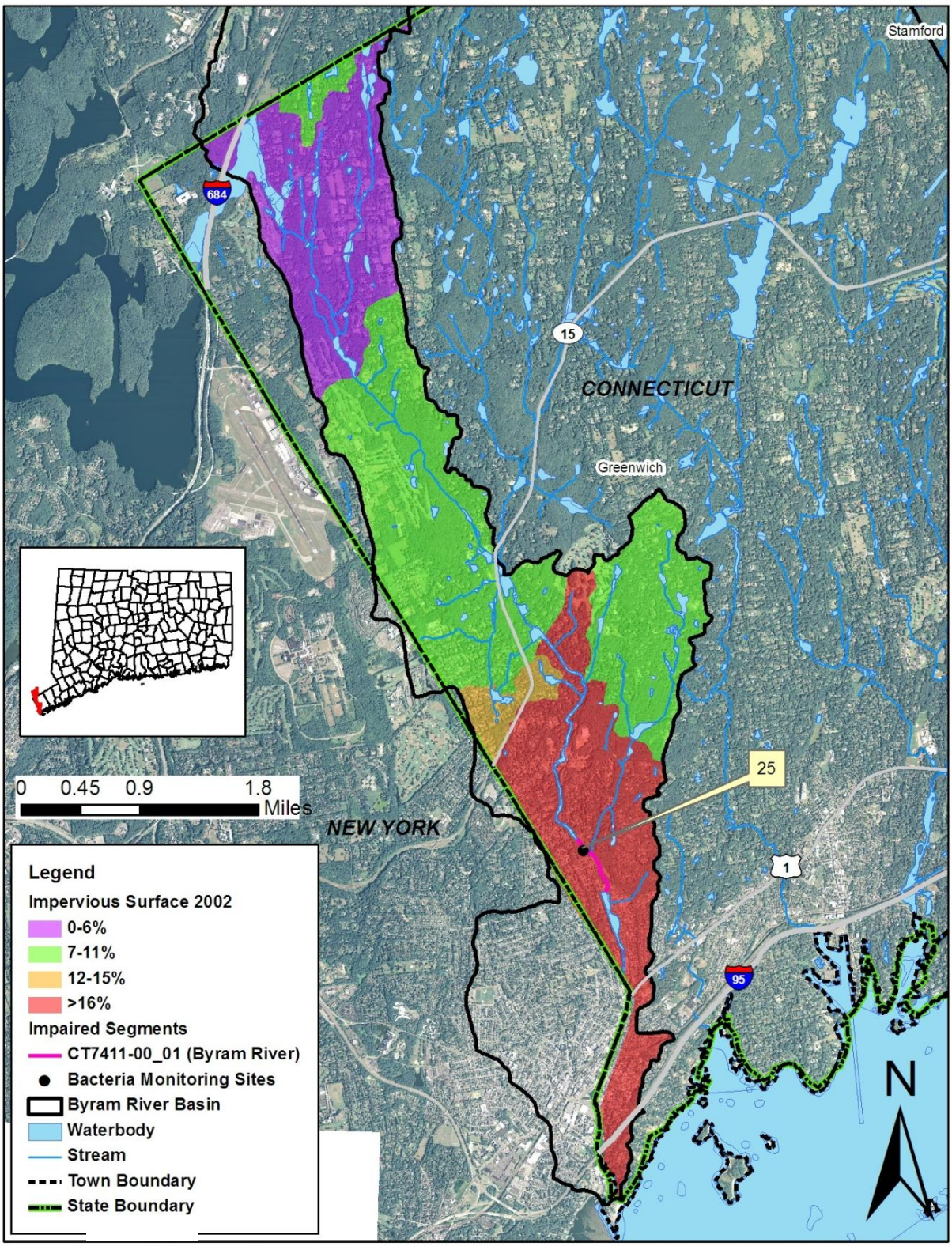


Figure 4: Impervious Surfaces In The Byram River Sub Regional Basin

Map Data: CT DEEP Map Created: July 2011

Insufficient Septic Systems and Illicit Discharges

As shown in Figure 6, only the southern portion of the watershed relies on the municipal sewer system. The majority of the northern portion of the watershed relies on onsite wastewater treatment systems, such as septic systems. Insufficient or failing septic systems can be significant sources of bacteria by allowing raw waste to reach surface waters. Upstream of the impaired segment is an area if development that is on septic systems. These locations include lots further north along Riversville Road, Bailiwick Road, Pecksland Road, Duncan Road, and additional parcels further north of these locations. In Connecticut, local health directors or health districts are responsible for keeping track of any reported insufficient or failing septic systems in a specific municipality. The Town of Greenwich has a full-time health director (http://www.greenwichct.org/HealthDept/HealthDept.asp).

The area surrounding the impaired segment of the Byram River is serviced by the municipal sewer system (Figure 6). Sewer system leaks and other illicit discharges or connections can contribute bacteria to nearby surface waters. Illicit sanitary connections to stormwater pipes were addressed as a significant problem in the Byram Watershed Management Plan (2011), especially in the lower portions of the watershed near the harbor.

High dry-weather *E. coli* geometric mean values may indicate the presence of failing and insufficient septic systems or illicit discharges that contribute bacteria to nearby waterbodies. As shown in Table 12, the geometric mean value for *E. coli* exceeded the WQS during dry-weather, indicating that a dry-weather source of bacteria, such as septic systems, is contributing bacteria to the Byram River.

Wildlife and Domestic Animal Waste

Wildlife and domestic animals within the Byram River watershed represent another potential source of bacteria. With the construction of roads and drainage systems, these wastes may no longer be retained on the landscape, but instead may be conveyed via stormwater to the nearest surface water. These physical land alterations can exacerbate the impact of natural sources on water quality (USEPA, 2001). As the majority of the watershed is undeveloped, wildlife waste is a potential source of bacteria to the Byram River. The Round Hill Country Club and Fairview Country Club are located within the Byram River watershed upstream of the impaired segment (Figure 6). Geese and other waterfowl are known to congregate in open areas including agricultural crop fields, recreational fields, and golf courses. These areas may provide suitable habitat for flocks of geese to gather for extended periods of time. In addition to creating a nuisance, large numbers of geese can also create unsanitary conditions on the grassed areas and cause water quality problems due to bacterial contamination associated with their droppings. Large populations of geese can also lead to habitat destruction as a result of overgrazing on wetland and riparian plants. Much of the residential development in the watershed is located near the Byram River. Waste from domestic animals, such as dogs, may also be contributing to bacteria concentrations in the impaired segment of the Byram River.

Agricultural Activities

Agricultural operations are an important economic activity and landscape feature in many areas of the State. Runoff from agricultural fields may contain pollutants such as bacteria and nutrients (USEPA, 2011a). This runoff can include pollutants from farm practices such as storing manure, allowing livestock to wade in nearby waterbodies, applying fertilizer, and reducing the width of vegetated buffer along the shoreline. Agricultural land use makes up 2% of the Byram River watershed. Although there are no major agricultural areas near the impaired segment, there are multiple agricultural fields and livestock farms located in the upper half of the Byram River watershed. Agricultural activities are most likely a

small source of bacteria to Byram River; however, large horse farms near the river, such as those on Riversville Road, should be monitored for potential contamination.

Additional Sources

Holly Hill Resource Recovery Facility is located downstream of the impaired river segment, but may be a high contributor of bacteria to impaired segments in the Byram River identified in Long Island Sound by the Byram Watershed Management Plan (BWC, 2011). As shown in Table 6, Holly Hill Resource Recovery Facility showed consistently high bacteria levels (>50,000 col/100mL fecal coliform) in 2002 at 3 discharge locations. This town-owned facility operates a waste disposal and recycling program for residents to bring their trash, garbage, refuse, yard debris, and recyclables. There may be other sources not listed here or identified in Figure 6 that contribute to the observed water quality impairment in the Byram River. Further monitoring and investigation will confirm the listed sources and discover additional ones. More detailed evaluation of potential sources is expected to become available as activities are conducted to implement this TMDL.

Land Use/Landscape

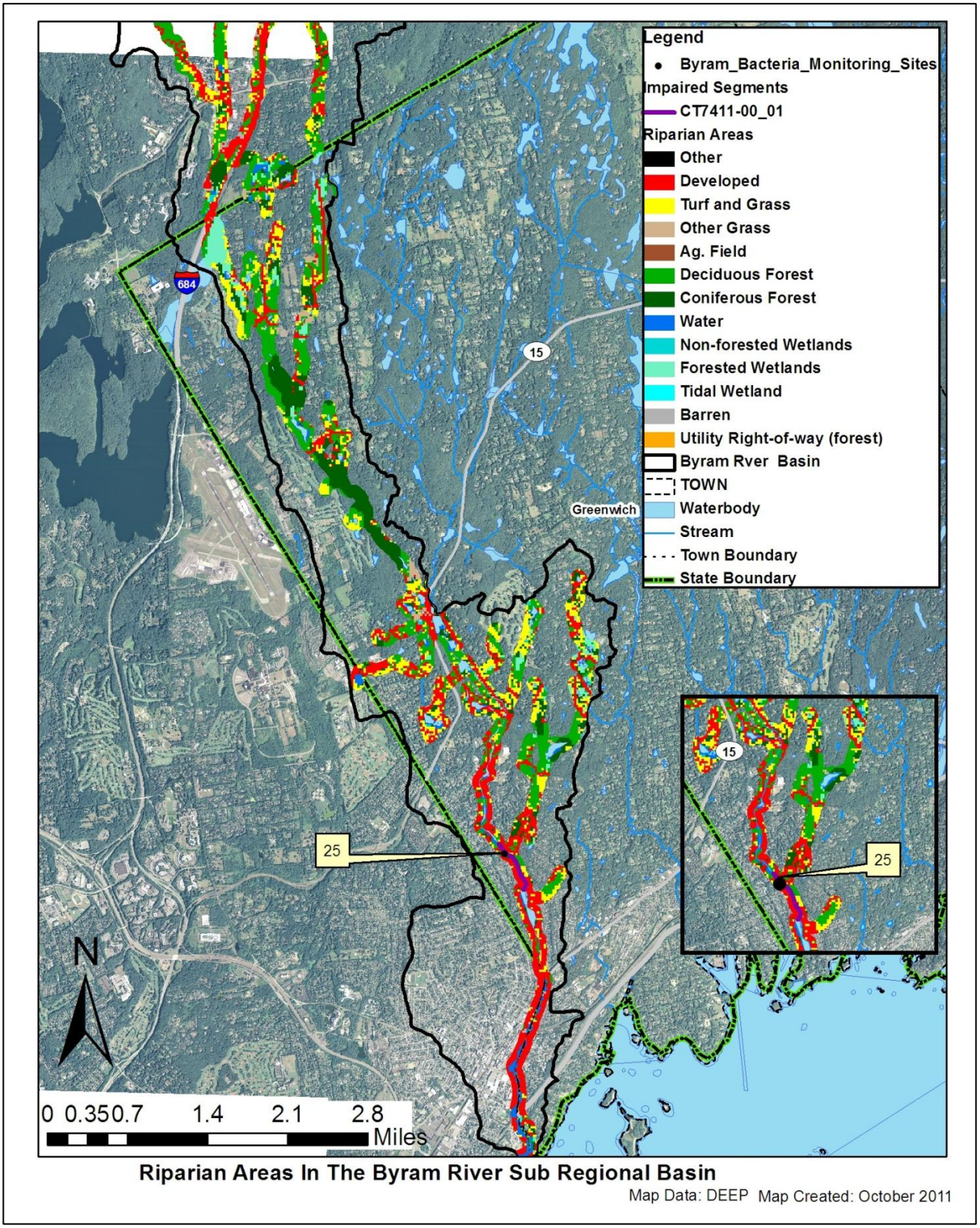
Riparian Buffer Zones

The riparian buffer zone is the area of land located immediately adjacent to streams, lakes, or other surface waters. The boundary of the riparian zone and the adjoining uplands is gradual and not always well-defined. However, riparian zones differ from uplands because of high levels of soil moisture, frequent flooding, and the unique assemblage of plant and animal communities found there. Through the interaction of their soils, hydrology, and vegetation, natural riparian areas influence water quality as contaminants are taken up into plant tissues, adsorbed onto soil particles, or modified by soil organisms. Any change to the natural riparian buffer zone can reduce the effectiveness of the natural buffer and has the potential to contribute to water quality impairment (USEPA, 2011b).

The CLEAR program at UCONN has created streamside buffer layers for the entire State of Connecticut (http://clear.uconn.edu/), which have been used in this TMDL. Analyzing this information can reveal potential sources and implementation opportunities at a localized level. The land use directly adjacent to a waterbody can have direct impacts on water quality from surface runoff sources.

The majority of the riparian zone for the impaired segment of the Byram River is characterized by developed land use (Figure 10). Riparian areas upstream of this impaired segment are also characterized by developed land use with small portions of deciduous forested and turf/grass areas. As previously noted, if not properly treated, runoff from developed areas may contain pollutants such as bacteria and nutrients.

Figure 10: Riparian buffer zone information for the Byram River watershed



UCONN CLEAR: http://clear.uconn.edu/

CURRENT MANAGEMENT ACTIVITIES

The Town of Greenwich has developed and implemented programs to protect water quality from bacterial contamination. In 2011, the Byram River Watershed Management Plan was completed (BWC, 2011). This document outlines current actions in the watershed and recommends future actions necessary to maintain or improve water quality.

CT DEEP's Non-Point Source Pollution Program administers a Non-Point Source Grant Program with funding from EPA under Section 319 of the Clean Water Act (319 grant). A 319 grant was awarded to the Byram Watershed Coalition in 2010 to develop a watershed based plan for implementation actions. The WBP was completed in September 2011 and can be found at http://www.ct.gov/dep/lib/dep/water/watershed_management/wm_plans/byram_wbp2012att.pdf.

As indicated previously, Greenwich is regulated under the MS4 program. The MS4 General Permit is required for any municipality with urbanized areas that initiates, creates, originates or maintains any discharge of stormwater from a storm sewer system to waters of the State. The MS4 permit requires towns to design a Stormwater Management Plan (SMP) to reduce the discharge of pollutants in stormwater to improve water quality. The plan must address the following 6 minimum measures:

1. Public Education and Outreach.
2. Public Involvement/Participation.
3. Illicit discharge detection and elimination.
4. Construction site stormwater runoff control.
5. Post-construction stormwater management in new development and redevelopment.
6. Pollution prevention/good housekeeping for municipal operations.

Each town is also required to submit an annual update outlining the steps they are taking to meet the six minimum measures. All updates that address bacterial contamination in the watershed are summarized in Table 9. In addition to the updates listed in the tables, the Town of Greenwich, in cooperation with Columbia University, received American Recovery and Reinvestment Act funding and a NYSDEC 604(b) grant to conduct sampling in 2010 at 10 locations along the Byram River for use in water quality modeling. All final report materials should be reviewed for additional information that can supplement this TMDL.

Table 9: Summary of MS4 requirement updates related to the reduction of bacterial contamination from Greenwich, CT (Permit # GSM000084)

Minimum Measure	Greenwich Annual Report (March 2011)
Public Outreach and Education	1) Developed and distributed updated watershed management brochure. 2) Conducted half day seminar on stormwater manual modifications and alternate design approaches for LID. 3) Held series of training programs for local landowners as part of ongoing goose management program. 4) Updated website to include better information and links on stormwater management.

Table 9: Summary of MS4 requirement updates related to the reduction of bacterial contamination from Greenwich, CT (Permit # GSM000084) (continued)

Minimum Measure	Greenwich Annual Report (March 2011)
Public Involvement and Participation	1) Continued to discuss updates to Stormwater Drainage Manual. 2) Held public information meetings on new stormwater zoning regulations involving definition of lot coverage and severe grading to add floor area. 3) Conducted training program for volunteer stream walk assessments using USDA-RCS protocol. 4) Submitted draft watershed management plan in October 2010.
Illicit Discharge Detection and Elimination	1) All outfalls mapped. 2) Continued execution of watershed inspections and illicit discharge identification. 3) Outfall inspection and dry-weather monitoring complete, and the Town continues to monitor systems. 4) Completed initial draft of the Illicit Discharge and Connection - Stormwater Ordinance, and ordinance is ready for adoption.
Construction Site Stormwater Runoff Control	1) Continued to monitor for illicit discharges through routine maintenance. 2) All development plans reviewed to ensure compliance with stormwater regulations, especially as new Drainage Manual and LID regulations become effective.
Post Construction Stormwater Management	1) Adopted Municipal Fine Ordiance, which applies an additional filing fee based on percentage of earth disruption over a total lot area. 2) New Drainage Manual includes LID implementation regulations to limit impervious cover. 3) Hired consultant to provide GIS training to improve software for analysis of target communities and watershed protection.
Pollution Prevention and Good Housekeeping	1) DPW implemented a Computer Maintenance Management System to allow the collection of detailed maintenance information. 2) Continued street sweeping program so all town streets are swept at least twice per year. 3) Performed annual BMP and pollution prevention training of town employees. 4) Minimized use of salt on roads in winter. 5) Will perform audits on all Town Facilities in 2011.

RECOMMENDED NEXT STEPS

The Town of Greenwich has developed and implemented programs to protect water quality from bacterial contamination. Future mitigative activities are necessary to ensure the long-term protection of the Byram River and have been prioritized below. Some of these actions are provided in more detail in the 2011 Byram River Watershed Management Plan (http://www.ct.gov/dep/cwp/view.asp?A=2719&Q=379296).

1) Continue monitoring of permitted sources.

Previous discharge sampling from Holly Hill Resource Recovery Facility has shown elevated levels of fecal coliform bacteria, an indicator of bacterial pollution (Table 7). Further monitoring will provide information essential to better locate, understand, and reduce pollution sources. If any current monitoring is not done with appropriate bacterial indicator based on the receiving water, then a recommended change during the next permit reissuance is to include the appropriate indicator species. If facility monitoring indicates elevated bacteria, then implementation of permit required, and voluntary measures to identify and reduce sources of bacterial contamination at the facility are an additional recommendation. Regular monitoring should be established for all permitted sources to ensure compliance with permit requirements and to determine if current requirements are adequate or if additional measures are necessary for water quality protection.

Section 6(k) of the MS4 General Permit requires a municipality to modify their Stormwater Management Plan to implement the TMDL within four months of TMDL approval by EPA if stormwater within the municipality contributes pollutant(s) in excess of the allocation established by the TMDL. For discharges to impaired waterbodies, the municipality must assess and modify the six minimum measures of its plan, if necessary, to meet TMDL standards. Particular focus should be placed on the following plan components: public education, illicit discharge detection and elimination, stormwater structures cleaning, and the repair, upgrade, or retrofit of storm sewer structures. The goal of these modifications is to establish a program that improves water quality consistent with TMDL requirements. Modifications to the Stormwater Management Plan in response to TMDL development should be submitted to the Stormwater Program of DEEP for review and approval.

Table 10 details the appropriate bacteria criteria for use as waste load allocations established by this TMDL for use as water quality targets by permittees as permits are renewed and updated, within the Byram River watershed.

For any municipality subject to an MS4 permit and affected by a TMDL, the permit requires a modification of the SMP to include BMPs that address the included impairment. In the case of bacteria related impairments municipal BMPs could include: implementation or improvement to existing nuisance wildlife programs, septic system monitoring programs, any additional measures that can be added to the required illicit discharge detection and elimination (IDDE) programs, and increased street sweeping above basic permit requirements. Any non-MS4 municipalities can implement these same types of initiatives in effort to reduce bacteria source loading to impaired waterways.

Any facilities that discharge non-MS4 regulated stormwater should update their Pollution Prevention Plan to reflect BMPs that can reduce bacteria loading to the receiving waterway. These BMPs could include nuisance wildlife control programs and any installations that increase surface infiltration to reduce overall stormwater volumes. Facilities that are regulated under the Commercial Activities Stormwater Permit should report any updates to their SMP in their summary documentation submitted to DEEP.

Table 10. Bacteria (e.coli) TMDLS, WLAs, and LAs for Recreational Use

		Instantaneous *E. coli* (#/100mL)						Geometric Mean *E. coli* (#/100mL)	
Class	**Bacteria Source**	**WLA[6]**			**LA[6]**			**WLA[6]**	**LA[6]**
	Recreational Use	**1**	**2**	**3**	**1**	**2**	**3**	**All**	**All**
B[4]	Non-Stormwater NPDES	235	410	576				126	
	CSOs	235	410	576				126	
	SSOs	0	0	0				0	
	Illicit sewer connection	0	0	0				0	
	Leaking sewer lines	0	0	0				0	
	Stormwater (MS4s)	235[7]	410[7]	576[7]				126[7]	
	Stormwater (non-MS4)				235[7]	410[7]	576[7]		126[7]
	Wildlife direct discharge				235[7]	410[7]	576[7]		126[7]
	Human or domestic animal direct discharge[5]				235	410	576		126

(1) **Designated Swimming.** Procedures for monitoring and closure of bathing areas by State and Local Health Authorities are specified in: Guidelines for Monitoring Bathing Waters and Closure Protocol, adopted jointly by the Department of Environmental Protections and the Department of Public Health. May 1989. Revised April 2003 and updated December 2008.

(2) **Non-Designated Swimming.** Includes areas otherwise suitable for swimming but which have not been designated by State or Local authorities as bathing areas, waters which support tubing, water skiing, or other recreational activities where full body contact is likely.

(3) **All Other Recreational Uses.**

(4) Criteria for the protection of recreational uses in Class B waters do not apply when disinfection of sewage treatment plant effluents is not required consistent with Standard 23. (Class B surface waters located north of Interstate Highway I-95 and downstream of a sewage treatment plant providing seasonal disinfection May 1 through October 1, as authorized by the Commissioner.)

(5) Human direct discharge = swimmers

(6) Unless otherwise required by statute or regulation, compliance with this TMDL will be based on ambient concentrations and not end-of-pipe bacteria concentrations

(7) Replace numeric value with "natural levels" if only source is naturally occurring wildlife. Natural is defined as the biological, chemical and physical conditions and communities that occur within the environment which are unaffected or minimally affected by human influences (CT DEEP 2011a). Sections 2.2.2 and 6.2.7 of this Core Document deal with BMPs and delineating type of wildlife inputs.

2) Identify areas along the developed portions of the Byram River to implement Best Management Practices (BMPs) to control stormwater runoff.

As noted previously, 54% of the Byram River watershed is considered urban, and the Town of Greenwich is a MS4 community regulated by the MS4 program. The lower portion of the watershed near the impaired segment has an impervious cover greater than 16%. As such, stormwater runoff is most likely contributing bacteria to the waterbodies.

The Byram River Watershed Management Plan (2011) made specific recommendations to reduce the impacts of stormwater runoff on water quality (BWC, 2011). The plan recommended adopting stormwater ordinances in the watershed, determined a target reduction of 12% impervious cover per major stream segment, and highlighted multiple areas to install structural BMPs. The suggested BMPs within the watershed towns are listed in Table 11. In addition, a stream survey identified two additional outfalls (one draining from an oil delivery truck fleet downstream of Route 1 Bridge and the other draining from an eroding stone wall south of Route 1 Bridge) that should be further investigated for sewage or oil contamination.

Table 11: Recommended structural BMPs in Greenwich from the 2011 Byram River Watershed Management Plan

Location	Town	Recommended BMPs
Comely Avenue Commercial Building Parking Lot	Greenwich	Design a sand or biofiltration treatment unit on the SE corner of the parking lot to filter stormwater runoff.
Outfall near 26 Caroline Place	Greenwich	Install secondary treatment and stormwater retrofit to deepen standard catch basin sump with enhanced hooded outlet for greater capture.
Outfall near 67 Caroline Place	Greenwich	Install a forebay and created wetland system for primary treatment of contaminants.
Outfall near 2 Garden Place	Greenwich	Install primary treatment for bioretention of stormwater runoff.
Outfall near 99 Moncia Road	Greenwich	Install primary treatment as a gabion forebay.
Parking lot at 777 Putnma Avenue West	Greenwich	Install stormwater treatment facility of bioretention or sand filtration, and modify existing planting beds to rain gardens.
Outfall at north end of parking lot at 777 Putnam Avenue West	Greenwich	Install stormwater treatment facility of bioretention or sand filtration.
Pocket Park on South Water Street	Greenwich	Assess structural stability of bulkhead and install stormwater retrofit for biofiltration.
Den Road	Greenwich	Install biodetention or first flush filtration treatment for stormwater.
Stream Channel Modifications	Greenwich	Assess channel banks for stone wall or rip rap structures that may be contributing to flash floods.
Haleck Street	Greenwich	Install biofiltration unit as part of Army Corp of Engineers berm and tide gate valve project.
Comely Avenue and Pemberwick Road	Greenwich	Install bioretention unit or sand filter between road and river.
Toll Gate Pond near Route 15, Caroline Pond near Pemberwick Road, and Western Greenwich Civic Center at Glenville Road	Greenwich	Evaluate areas for goose management opportunities.

To identify other areas that are contributing bacteria to the impaired segments, the towns should continue to conduct wet-weather sampling at stormwater outfalls that discharge directly to the impaired segments in the Byram River watershed. Outfalls that have previously shown high bacteria concentrations should be prioritized for BMP installation (Table 7). To treat stormwater runoff, the towns should identify areas along the impaired segment to install BMPs designed to encourage stormwater to infiltrate into the ground before entering the waterbodies. These BMPs would disconnect impervious areas and reduce pollutant loads to the river. More detailed information and BMP recommendations can be found in the core TMDL document.

3) Evaluate municipal education and outreach programs regarding animal waste.

As most of the Byram River watershed is developed, any education and outreach program should highlight the importance of managing waste from horses, dogs, and other pets and not feeding waterfowl and wildlife. The town and residents can take measures to minimize waterfowl-related impacts such as

allowing tall, coarse vegetation to grow in the riparian areas of the Byram River that are frequented by waterfowl. Waterfowl, especially grazers like geese, prefer easy access to water. Maintaining an uncut vegetated buffer along the shore will make the habitat less desirable to geese and encourage migration. In addition, any educational program should emphasize that feeding waterfowl, such as ducks, geese, and swans, may contribute to water quality impairments in the Byram River and can harm human health and the environment. Animal wastes should be disposed of away from any waterbody or storm drain system. BMPs effective at reducing the impact of animal waste on water quality include installing signage, providing pet waste receptacles in high-use areas, enacting ordinances requiring the clean-up of pet waste, and targeting educational and outreach programs in problem areas.

4) Develop a system to monitor septic systems.

Though the lower portion of the Byram River watershed relies on the municipal sanitary sewer system, most residents upstream of the impaired segment rely on septic systems, and a large septic leachfield has been identified upstream of the impaired segment. The Byram Watershed Coalition (BWC) is currently seeking funding to map all septic systems within the watershed, identify failing septic systems, and model potential hotspots according to soil loading characteristics. The Town of Greenwich should support this endeavor and work with the BWC if funding is obtained for the mapping projects. Inspections help encourage proper maintenance and identify failed and sub-standard systems. Policies that govern the eventual replacement of sub-standard systems within a reasonable timeframe can be adopted. Greenwich can also develop a program to assist citizens with the replacement and repair of older and failing systems.

5) Continue evaluation of the sanitary sewer system.

The lower portion of the Byram River watershed relies on a municipal sewer system. This area is concentrated in the southern half of the watershed surrounding the impaired segment (Figure 6). It is important for Greenwich to continue implementing and expanding their program to evaluate sanitary sewers and reduce leaks and overflows. Illicit sanitary connections to stormwater pipes were addressed as a significant problem in the Byram Watershed Management Plan (2011), especially in the lower portions of the watershed near the harbor (see Appendix 74). The Town of Greenwich is taking action to conduct routine sampling of storm drain catch basins, manholes and outfalls along the river. Greenwich is also conducting an ongoing investigation and correction of illegal sanitary connections to their sewer collection system. As of the writing of this document Town officials have found no evidence of illicit discharges connecting to the stormwater system

6) Ensure there are sufficient buffers on agricultural lands along the Byram River.

Although agricultural land use represents only 2% of the Byram River watershed, it may still be a concern for water quality, especially with an identified large horse farm within the riparian buffer zone of the Byram River and upstream of the impaired segment (Figure 11). If not already in place, agricultural producers should work with the CT Department of Agriculture and the U.S. Department of Agriculture Natural Resources Conservation Service to develop conservation plans for their farming activities within the watershed. These plans should focus on ensuring that there are sufficient stream buffers, that fencing exists to restrict access to livestock and horses to streams and wetlands, and that animal waste handling, disposal, and other appropriate Best Management Practices (BMPs) are in place.

BACTERIA DATA AND PERCENT REDUCTIONS TO MEET THE TMDL

Table 12: Byram River Bacteria Data

Waterbody ID: CT7411-00_01

Characteristics: Freshwater, Class B, Habitat for Fish and other Aquatic Life and Wildlife, Recreation, and Industrial and Agricultural Water Supply

Impairment: Recreation (*E. coli bacteria)*

Water Quality Criteria for E. coli:

Geometric Mean: 126 colonies/100 mL

Single Sample: 410 colonies/100 mL

Percent Reduction to meet TMDL:

Geometric Mean: **88%**

Single Sample: **98%**

Data: 2006-2009 from CT DEEP targeted sampling efforts, 2012 TMDL Cycle

Single sample *E. coli* (colonies/100 mL) data from Station 25 on the Byram River with annual geometric means calculated

Station Name	Station Location	Date	Results	Wet/Dry	Geomean
25	Downstream of Comley Avenue crossing	6/15/2006	890	wet**	916
25	Downstream of Comley Avenue crossing	6/21/2006	1300	dry**	
25	Downstream of Comley Avenue crossing	6/29/2006	2900	wet**	
25	Downstream of Comley Avenue crossing	7/12/2006	2000	wet**	
25	Downstream of Comley Avenue crossing	7/20/2006	1100	dry**	
25	Downstream of Comley Avenue crossing	7/27/2006	2000†	wet**	
25	Downstream of Comley Avenue crossing	8/3/2006	400	dry**	
25	Downstream of Comley Avenue crossing	8/10/2006	280	dry**	
25	Downstream of Comley Avenue crossing	8/17/2006	535†	dry**	
25	Downstream of Comley Avenue crossing	8/24/2006	470	dry**	

Single sample *E. coli* (colonies/100 mL) data from Station 25 on the Byram River with annual geometric means calculated (continued)

Station Name	Station Location	Date	Results	Wet/Dry	Geomean
25	Downstream of Comley Avenue crossing	6/17/2007	220	dry	**1069* (88%)**
25	Downstream of Comley Avenue crossing	6/20/2007	730	dry	
25	Downstream of Comley Avenue crossing	7/5/2007	700	wet	
25	Downstream of Comley Avenue crossing	7/11/2007	430†	dry	
25	Downstream of Comley Avenue crossing	7/19/2007	1500†	wet	
25	Downstream of Comley Avenue crossing	7/26/2007	200	dry	
25	Downstream of Comley Avenue crossing	8/8/2007	**24000* (98%)**	wet	
25	Downstream of Comley Avenue crossing	8/22/2007	1000	wet	
25	Downstream of Comley Avenue crossing	9/10/2007	6100	dry**	
25	Downstream of Comley Avenue crossing	9/20/2007	920†	dry**	
25	Downstream of Comley Avenue crossing	6/2/2008	94†	dry**	225
25	Downstream of Comley Avenue crossing	6/11/2008	570	dry**	
25	Downstream of Comley Avenue crossing	6/18/2008	270†	wet**	
25	Downstream of Comley Avenue crossing	6/25/2008	190	wet**	
25	Downstream of Comley Avenue crossing	7/2/2008	160	dry**	
25	Downstream of Comley Avenue crossing	7/9/2008	390	dry**	
25	Downstream of Comley Avenue crossing	7/17/2008	230	dry**	
25	Downstream of Comley Avenue crossing	7/30/2008	115†	dry**	
25	Downstream of Comley Avenue crossing	8/5/2008	74	dry	
25	Downstream of Comley Avenue crossing	8/13/2008	31	dry	
25	Downstream of Comley Avenue crossing	8/20/2008	7300	dry	

Single sample *E. coli* (colonies/100 mL) data from Station 25 on the Byram River with annual geometric means calculated (continued)

Station Name	Station Location	Date	Results	Wet/Dry	Geomean
25	Downstream of Comley Avenue crossing	6/17/2009	150	dry**	223
25	Downstream of Comley Avenue crossing	6/24/2009	230	dry**	
25	Downstream of Comley Avenue crossing	7/1/2009	160	wet**	
25	Downstream of Comley Avenue crossing	7/22/2009	370	wet**	
25	Downstream of Comley Avenue crossing	8/5/2009	270	dry**	
25	Downstream of Comley Avenue crossing	8/12/2009	460	dry**	
25	Downstream of Comley Avenue crossing	8/19/2009	30†	dry**	
25	Downstream of Comley Avenue crossing	9/3/2009	370	dry**	
25	Downstream of Comley Avenue crossing	9/9/2009	485†	dry**	

Shaded cells indicate an exceedance of water quality criteria

†Average of two duplicate samples

**** Weather conditions for selected data taken from Hartford because local station had missing data**

***Indicates single sample and geometric mean values used to calculate the percent reduction**

Wet and dry weather *E. coli* (colonies/100 mL) geometric mean values for Station 25 on Byram River

Station Name	Station Location	Years Sampled	Number of Samples		Geometric Mean		
			Wet	Dry	All	Wet	Dry
25	Downstream of Comley Avenue crossing	2006-2009	12	28	474	981	347

Shaded cells indicate an exceedance of water quality criteria

Weather condition determined from rain gauges at Stamford 5 N station in Stamford, CT and at Hartford Bradley International Airport

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